MILITARY BASE CLOSURE HANDBOOK

A GUIDE TO CONSTRUCTION AND DEMOLITION MATERIALS RECOVERY

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CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
INTEGRATED WASTE MANAGEMENT BOARD

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TABLE OF CONTENTS

I. INTRODUCTION

A. Background ... 1

B. Waste Issues ... 1

II. WASTE STREAM MANAGEMENT

A. Introduction ... 2

B. Waste Stream Characteristics ... 2

1. Demolition Waste ... 2
2. Construction Waste ... 6

C. References ... 7

III. BUILDING DEMOLITION

A. Introduction ... 7

B. Demolition Stages ... 8

1. Placing Bids and Obtaining Permits ... 8
2. Clearing Salvageable Items and Taking Down the Building ... 8
3. Size-Reducing and Segregating Materials ... 8
4. Hauling Demolition Debris ... 8
5. Site Clearance ... 9

C. Structure Types ... 9

1. Wood Frame ... 9
2. Wood and Masonry ... 9
3. Semifireproof and Fireproof ... 9

D. Demolition Methods ... 9

IV. CONTRACTING

A. Contracting Process ... 10

B. Commonly Used Contracting Approaches for Materials Recovery ... 10

1. Standard Contract Process ... 10
2. Contract, Then Negotiate for Recycling Component ... 10
3. Two-Step Approach: Deconstruction, Then Demolition ... 11
4. Contracting with Recycling Preferences Based on Specified Performance Goals ... 11

V. End Uses and Markets

A. Processing **12**
B. End Uses **12**
1. Asphalt 12
2. Recycled Aggregate 12
3. Wood 13
4. Drywall 13
5. Metal 13
C. Reuse **15**

VI. Case Study: Presidio of San Francisco, Building 901

A. Background **16**
B. Building 901 Overview **16**
C. Site Visits **17**
D. Materials Recovered **20**
E. Project Economics **20**
F. Conclusions **22**

VII. Appendices

A. Demolition Methods **24**
1. Introduction 24
2. Manual Wrecking 24
3. Mechanical Wrecking 24
4. Thermal Wrecking 25
5. Explosive Wrecking 25
B. Processing Techniques **25**
1. Introduction 25
2. General 25
3. Specific C&D Materials 26
4. Equipment 27
5. References 29
C. Sample Instructions to Proposers: Port of Portland **30**
D. Lists **37**
E. Fact Sheets **38**

I. INTRODUCTION

A. Background

As a result of downsizing the nation's military forces, twenty-nine bases in California will be closed or realigned by the year 2001. The statewide impacts of defense downsizing are enormous. According to a recent report to the Governor, base closure and realignment activities are expected to result in a loss of 200,000 service-related jobs, accompanied by a loss in personal income approaching $7 billion. An additional 200,000–400,000 civilian job will be lost due to cuts in prime defense contracting.

Despite such unsettling repercussions, base closures and realignments can present unique opportunities to local communities and California businesses. Over 74,000 acres of land will be available for alternative uses. Appurtenant facilities include airfields, hangers, office buildings, and family dwellings supported by roads, sewer systems and functional utilities. These resources, once limited to use by the military, are now available for use by local communities throughout the state. They can be magnets, attracting new business to affected communities and spurring commercial growth offsetting the negative economic impact of defense downsizing both regionally and statewide.

B. Waste Issues

Redevelopment activities attributable to base closures are generating substantial amounts of waste. The California Integrated Waste Management Act of 1989 requires cities and counties to divert 50 percent of their waste streams from landfills by the year 2000. The surge in waste materials coming from base conversion projects can drastically impact some communities' ability to achieve that goal.

Recognizing that a large portion of these newly generated waste materials can be reused or recycled, and responding to a Governor's directive encouraging State participation in base reuse activities (Executive Order W-81-94), the California Integrated Waste Management Board (CIWMB) is promoting cost-effective, environmentally safe alternatives to land disposal. The CIWMB works closely with local governments and private businesses to reduce the amount of waste going into the state's landfills. In addition to its statewide oversight responsibilities for solid waste handling and disposal, the CIWMB implements a number of programs designed to develop markets for reusable and recyclable waste materials. In the past five years alone, the efforts of the CIWMB and its public and private partners have resulted in a statewide decrease of 25 percent in the amount of waste going to landfills. The goal of this handbook is to inform those involved in base conversion activities of the CIWMB's partnership and program resources to promote alternatives to disposal of conversion-generated waste.

How to Use This Handbook

This handbook is a guide for policy makers, administrative staff, and technical personnel involved in military base conversion activities in their efforts to find cost-effective, environmentally protective alternatives to disposal of demolition debris. Redevelopment activities accompanying base conversions generate large amounts of demolition waste that is potentially reusable or recyclable. The centralized nature and scale of base conversion projects make these undertakings particularly well suited to reuse and recycling options. Much waste material generated during redevelopment can be reused in new construction or recycled into new products. Recovery and reuse of old building materials also minimizes the amount of waste going into landfills, thereby saving landfill space and avoiding disposal costs.

This handbook provides timely "how to" information to base conversion officials to facilitate waste reuse and recycling. It follows a practical approach, focusing on economically viable closed-loop waste reduction, reuse and recycling techniques that will keep waste out of landfills.

The document will be updated as necessary to reflect the most current information available and ongoing development. Each section and the materials therein are intended to stand alone, allowing for easy reference and for insertion of new and updated materials as necessary.

II. Waste Stream Management

A. Introduction

The types and quantities of waste generated from demolition, construction, and renovation activities occurring at military bases throughout the state varies depending on the facility, the structures on site, and activities occurring there. No exact formula or characteristics can be quoted for the types of waste that will be generated from base closure activities. General waste characteristics can be estimated from construction and demolition waste characterization studies performed throughout the country.

Construction waste characteristics vary, but in general, the primary components include wood, gypsum, cardboard, masonry, mixed waste (trash and other materials), metal, and other building materials (roofing, plastic, glass, etc.). The largest portion of the construction waste stream, by far, can be attributed to wood, gypsum, and masonry. The remaining components of the construction waste stream will vary depending on the type of structure and the method by which it is being constructed.

Demolition waste characteristics are also entirely dependent on the type of structures being demolished and the extent and method of demolition being practiced. Wood and masonry (composed primarily of brick and concrete) are generally the largest portions of this waste stream. Lesser percentages are composed of gypsum, paper, glass, plastics, asphalt, various roofing materials, and mixed wastes.

The presence of special or hazardous materials can be an additional concern when analyzing the makeup of demolition waste found on military facilities. Due to the vintage of military facilities, many structures on military bases contain both lead-based paint and asbestos. Because of the presence of these materials, additional measures and precautions are necessary to both demolish a structure and/or recover materials for reuse and recycling from that structure. This, in turn, tends to increase the time needed and the cost to perform these activities.

In addition to the waste materials and hazardous materials outlined above, closure of military facilities and the resulting demolition activities can generate wastes similar to those found in any other commercial or residential structure. These items can include major appliances, heating and air conditioning equipment and ducting, furniture, carpet and flooring, wiring, plumbing, and other fixtures. These items can sometimes be sold or salvaged prior to large scale demolition or deconstruction.

(The data and quantities and characteristics of construction and demolition waste documented in this section are either direct quotes or compilations of information contained in the referenced documents listed in Section C.)

B. Waste Stream Characteristics

As stated above, exact quantification of materials generated from demolition or construction operations is impossible. Even site specific-quantities are estimates that are only as accurate as the experience of the estimator will allow. However, data have been collected quantifying amounts and types of waste generated from the construction and demolition of various structures. These data can be used as a rough indicator of the expected waste streams for similar structures on military facilities.

1. Demolition Waste

As might be expected, the waste generated from base demolition activities is similar in its characteristics to construction waste. The principal materials being generated and recovered during demolition activities include wood, metal, masonry, dirt, paperboard, and mixed waste. While construction waste tends to be generated in phases, demolition wastes are generated in large batches or by layers if deconstruction techniques are used. Deconstruction is characterized by the dismantling of a structure in a fashion that maximizes the recovery of materials and recycling. Conversely, if mechanized demolition is used, the resulting material tends to be commingled and can include nonstructural waste materials such as appliances, fixtures, and furniture.

a) General Demolition Quantities

The quantities of material generated from demolition activities are generally proportional to the size of the structure being demolished. However, the examples listed below can be used to estimate the makeup of the material that will be generated for various types of buildings. This information can then be used to determine future processing needs to achieve higher rates of material recovery.

(The examples summarized below do not appear to include either fixtures or equipment that might be expected from the demolition of structures at military bases. Other materials might include glass, insulation, roofing materials, green waste, flooring, and special materials such as lead-based paint, asbestos, and chemically treated wood.)

In general, demolition activities generate far more waste per square foot than construction activities, and the waste is more difficult to reuse or recycle. Preliminary studies of residential demolition and commercial renovation (tenant improvement and gut-and-rebuild) calculate waste generation rates far beyond construction waste generation studies. Commercial renovation waste was generated at rates ranging from 8.4 lb/ft2 to 11.5 lb/ft2 while residential demolition yielded waste generation estimates as high as 72 lbs/ft2.

b) Wood Structures

Residential

A study by the University of Chicago on the demolition of 18 residential wood homes reported that almost 80 percent of the waste generated was wood waste. The remainder of the waste stream was composed of 3 percent metal, 13 percent brick, and 4 percent concrete. Other residential demolition studies of waste generation have found as little as 21 percent wood, 33 percent rubble, 22 percent waste, and 22 percent salvage.

Commercial

The demolition of three wood-structured commercial buildings resulted in a waste stream. The commercial wood building demolition yielded 73 percent wood, 3 percent metal, 18 percent brick, and 7 percent concrete. There is considerable potential to recover wood for reuse or recycling. The primary barrier to recovering the wood, or any material, is finding cost-effective techniques that will remove the material from the structure in a usable state. (More specific discussions of demolition techniques are contained in Section IV and the Appendices in Section IX.)

c) Brick Structures

The demolition and quantification of waste generated from four residential brick structures resulted in the following waste stream makeup: 73 percent of the waste was brick, 23 percent wood, 2 percent metal, and 3 percent paperboard. Similarly, the demolition of 9 commercial brick buildings resulted in the following characterization: 71 percent brick, 20 percent concrete, 12 percent wood, 3 percent metal, and 1 percent paperboard.

d) Concrete Structures

The characterization of the waste resulting from the demolition of four commercial concrete buildings resulted in the following percentages: 51 percent concrete, 22 percent brick, 18 percent wood, 3 percent metal, and 5 percent paperboard.

e) Regional Variation

The type of structures found on military facilities and the materials that make up those structures, will vary significantly depending on the mission of the facility and the vintage of the structures. Regional building styles can dictate, to a certain degree, what can be economically recovered from a deconstruction project. For example, stucco exteriors are common in Southern California because of the prevalence of Spanish-style architecture. As a result, the amount of wood recovered will be less than the amount recovered from a wood-sided, wood frame building. This is just one of the factors that should be considered when evaluating material recovery rates of structures throughout California. These factors could include: climate, seismic activity in the region, and building styles. These factors can dictate the amount of materials used, types of materials and insulation needed, as well as heating, ventilating, and air-conditioning equipment and plumbing requirements. All these should be considered when evaluating the reuse and recyclability of components that make up the building.

f) Other Structures

Large-scale demolition on military facilities often includes the demolition of improvements and structures other than those mentioned above. Large military facilities often contain large paved or concrete areas which served as air fields, heliports, roads, or parade grounds. Many of these improvements will be removed, generating huge amounts of concrete and asphalt waste. Depending on the building projects proposed, much of this material can be reprocessed and used on site. Asphalt can be crushed and recycled and incorporated into new asphalt pavement or processed into recycled aggregate. Similarly, concrete can be processed to make recycled aggregate. The aggregate can be used for base or sub-base under new roads or for parking lots on site.

g) Special Materials

When demolishing older structures, often found on military installations, the issue of addressing special materials such as asbestos, lead-based paint, and treated wood will often arise. These special materials make reuse or recycling more difficult and expensive, and may increase disposal costs. It is generally true that the contamination must be removed and encapsulated. Commingling of the wastes must be minimized to maximize reuse of the uncontaminated materials. General guidelines for addressing each special waste are as follows:

Lead-Based Paint

Exposed wood in structures is usually painted to protect it from the elements, which in itself makes reuse more difficult. When the paint contains lead, the potential problem of having to deal with hazardous materials becomes part of the equation.

If a structure was built before 1978, there is a potential that it is coated with lead-based paint. If it was built before 1960, it is even more likely that it was coated with lead-based paint. Furthermore, paints produced before 1960 contain higher concentrations of lead than lead-based paints produced in later years.

The Department of Toxic Substances Control (DTSC) issued clarifying language regarding lead-based paint in Regulation Guidance: Lead Painted Building Debris dated June 13, 1994. "The Department does not generally expect intact painted building materials to exhibit a characteristic of a hazardous waste pursuant to the criteria contained in Chapter 11, Division 4.5, Title 22, California Code of Regulations (Title 22) and would not require the disposal of intact painted material as a hazardous waste. The waste classification is dependent, in part, upon the physical characteristics of the waste. For example, when the paint is still bonded to the building materials, a generator should consider the ratio of the mass of all the materials in a waste to the lead content of the paint when determining the hazardous waste classification of the intact demolition debris. However, if during the demolition or dismantling of the buildings, the paint is separated from the building material (e.g., chemically or physically removed), then the paint waste should be evaluated independently from the building material to determine its proper management." DTSC also states that it is the generator's responsibility to determine if his waste is hazardous or nonhazardous.

(To obtain documents relating to the sampling and classification of wastes, call DTSC's waste evaluation helpline at (916) 322-7676 or consult your telephone directory for regional offices of DTSC and contact the local duty officer.)

There are essentially three options available for reuse of lumber that is coated with lead-based paint. The first option is to remove the paint. This will leave the wood clean, but creates the problem of disposing of the now potentially hazardous residue. This option is usually only cost effective for large dimension lumber or unique timbers or fixtures. The second option is to encapsulate the lead paint by painting over it. This is considered an adequate remediation technique which eliminates the exposure pathway of the lead and allows use of the structure. However, if deconstruction or demolition is planned in the future, the lead-based paint will be exposed again. The third option for remediating lead painted materials for reuse is to reverse the painted surface to expose the unpainted portion of the lumber. This again eliminates the pathway for human contact, but would lead to re-exposure under demolition of the structure. Any paint removed from the structure has to be evaluated separately to determine if it is a hazardous material. Care must be taken not to contaminate surrounding soil or water.

If wood waste is going to be processed for mulch or biomass fuel, painted wood in general is highly undesirable. If disposal is the only remaining option, use the DTSC guidelines listed above and refer to the DTSC helpline to assist you determining which disposal option to take.

Asbestos

Asbestos is a naturally occurring mineral fiber that has been processed into numerous commercial products. The following is a list of some of the materials made from asbestos that would likely be found in residential and commercial structures:

Acoustic Ceilings. The material will often have a cottage cheese-like appearance. The asbestos-containing material can be in the form of tiles or sprayed on. The manufacture of these products was banned in 1978, but existing supplies were sold and used into the 1980s. Ceilings commonly contain 1-5 percent friable asbestos, but could have higher concentrations.

Furnace Duct and Furnace Insulation. Furnaces and ducts were often wrapped with either asbestos sheeting or paper (has a gray-white heavy paper appearance) or with aircells. The aircell also tends to be gray-white and looks similar to corrugated cardboard. The sheeting may contain 10-15 percent asbestos, while the aircells may contain up to 80 percent asbestos. The tape that covers the seams or binds the material to the duct may also contain asbestos. These products were banned in 1971.

Drywall Taping and Joint Compound. The drywall joint compound usually contains 10-15 percent asbestos. The manufacture of these materials was banned by 1978.

Textured Paints and Plaster. The texturing on walls was usually accomplished by spreading and texturing the joint compound referenced above.

Vinyl Flooring (Linoleum or Vinyl Tiles). Both these products and the glue (mastic) holding them to the floor commonly contain asbestos. The backing on the linoleum often contains 40-60 percent asbestos. Floor tiles may contain up to 15 percent asbestos. These products are still legally manufactured.

Pipe Lagging (Insulation) and Block Insulation. These materials are commonly found in larger, nonresidential, buildings but can also be in residential dwellings. Chalk and/or clay like materials are mixed with the asbestos and applied around hot water lines, boilers, and furnaces. This material was banned in 1971.

Asbestos can also be found in flexible fabric joints and paper tape on HVAC systems, window putty, asbestos-cement wallboard, asphalt roofing material and roofing felt, silver roof emulsion, pipe elbows, water heater vent seams, spray-applied fire proofing, and fire door insulation.

Asbestos is only a health concern when it is exposed, disturbed, and friable. Friable materials include spray acoustic ceilings, paper insulation on furnace ducting, and pipe insulation that is soft or crumbly type. Nonfriable materials include floor tile and hard, cement-like pipes and panels. Non-friable materials may become a health concern if the asbestos is liberated from the material matrix during demolition.

If a military base is turned over for civilian use, the military may remediate exposed friable asbestos. However, structures on site, such as barracks, may still contain friable asbestos that is either contained in or concealed under flooring or wall coverings. There is no immediate health concern unless the structure is subsequently demolished or renovated, exposing asbestos-containing materials. Additional care should be taken not to release asbestos particles into the air through subsequent processing of materials removed from structures.

Any contractor removing more than 100 square feet of asbestos must be registered with CAL-OSHA and licensed by the Contractor's State Licensing Board. For information regarding the registration of a contractor or a list of licensed contractors, refer to these agencies:

Cal/OSHA
455 Golden Gate Avenue
5th Floor, Rm 5227
San Francisco, CA 94102
(415) 972-8577

California Contractors State License Board
P.O. Box 2600
Sacramento, CA 95826
(916) 366-5153
1-800-321-2752

Disposal of asbestos-containing material is primarily the concern of the licensed contractor who should be aware of the licensing, remediation, encapsulation, transportation, and disposal requirements. For general information purposes, Cal/EPA defines asbestos waste (meaning it is hazardous) as having more than 1 percent asbestos and being friable. If the waste does not meet both of these criteria, it can be disposed of as normal waste in a Class III landfill. If it is friable and contains more than 1 percent asbestos, it must be disposed of in a landfill approved for hazardous waste, or the friable asbestos must be contained or encapsulated when removed. Several Class III landfills are permitted to accept encapsulated asbestos. The Bay Area Air Quality Management District maintains a list of active asbestos landfills in California. They can be reached at (415) 771-6000.

Treated Wood

Treated wood includes utility poles, railroad ties, and other construction wood treated with chemicals and preservatives to prevent wood rot. The chemicals used to treat the wood include pentachlorophenol, creosotes, and arsenic compounds. Examples of reuse applications include use as light poles, landscaping timbers, parking barriers, retaining walls, fences, and open-air pole barns.

Users should also be aware of the limitations on disposal and use of treated wood. The type and amount of preservative used to treat the wood may cause it to be classified and regulated as hazardous waste. If the chemicals in the treated wood are listed as a RCRA waste and exceed RCRA limitation, the treated lumber will have to be disposed of in a Class I landfill if it is not reused for its originally intended purpose. Treated wood that is not listed as a RCRA waste and is intended for disposal may be permitted for disposal at a Class II or Class III landfill if the landfill is lined, is willing to accept the waste, and is permitted to accept the waste by the Regional Water Quality Control Board.

If disposal is the only option left available, it must be determined whether the treated wood is classified as hazardous waste. For guidelines on determining if treated wood is hazardous waste, contact the Waste Evaluation Unit of DTSC at (916) 322-7676, or the duty officer in any of the following regional offices:

1. Region 1, Northern California, (916) 255-3618
2. Region 2, Bay Area, (510) 570-3739
3. Region 3, Burbank, (818) 551-2830
4. Region 4, Cypress, (714) 484-5400.

2. Construction Waste

General estimates can be made of the quantities and percentages of materials generated as a result of construction of new structures. The information can be used to evaluate the primary materials generated during construction. These materials include wood, gypsum, masonry, paper, and other construction-related wastes.

a) General Construction Waste Generation

The studies referenced below have arrived at some conclusions regarding the overall amounts of waste generated from new construction. Although waste generation is a site-specific function, the quantities are consistent enough to use as a baseline when estimating the amounts of waste that can be expected from new construction.

Waste characterization studies have found that new home construction generates between 3.5 and 4.7 lbs of waste per square foot of construction. As the size of projects increase, the waste per square foot of construction tends to decrease. Large commercial and apartment building projects generate 1.5 to 2.5 lbs of waste per square foot of new construction.

b) Wood Waste

Wood is generally the largest component of the construction waste stream. Various studies have shown that wood comprises roughly 40 percent of the material generated at construction sites. Wood home construction generates the most waste. The wood content in new home frame-construction waste ranges from 21 to 80 percent, with the average being about 50 percent. Conversely, commercial construction tends to generate a smaller percentage of wood waste, ranging from 8 to 30 percent of the content of the construction waste stream.

Wood waste generation resulting form renovation of commercial and residential structures averages 25 to 35 percent. (For information on wood waste recycling, refer to the fact sheets on urban wood waste and lumber found in Appendix F in Section IX of this handbook.)

c) Drywall

Drywall is another large portion of the construction waste stream. Drywall scraps represent 10 to 25 percent of the waste generated in new home construction. Current new construction practices result in approximately 12 percent of the drywall going to waste. This translates to approximately one pound of drywall waste for every square foot of building. Commercial construction tends to generate proportionately less drywall in the construction waste stream, roughly 5 to 10 percent of the total waste generated. For more information on recycling drywall, refer to the enclosed drywall fact sheet.

d) Other Materials

The remainder of materials in the construction waste stream include cardboard and paper products (2 to 15 percent), metals (<1 to 15 percent), masonry (1 to 25 percent), trash (~10 percent), plastics (2 to 8 percent), and various amounts of mixed waste and building materials. The amounts of mixed materials can range from negligible amounts to upwards of 40 percent of the waste stream, depending on the type of building project and on the efforts employed to both recover and identify the material that is generated.

C. References

1. "Construction Materials Recycling Guide Book: A Guide to Reducing and Recycling Construction and Demolition Waste," Metro Council of Twin Cities.

2. "Construction Industry Recycling Project," July 30, 1993, Metro Solid Waste Department (Portland, Ore.).

3. "Developing a Construction and Demolition Debris Recycling System for Disaster Debris Management," January 1994, Metro Solid Waste Department.

4. H.F. Fisher, McHenry County Department of Solid Waste Management, Woodstock, Ill., October 1992 interview.

5. "Construction and Demolition Waste: Generation, Regulation, Practices, Processes, and Policies," January 1993, University of Illinois, Chicago.

6. "Recycling Construction and Demolition Waste in Vermont," December 1990, Vermont Agency of Natural Resources, Montpelier, Vt.

7. "Draft Construction and Demolition Waste in Alameda County: A Status Report with Recommendations for Local Government Action," November, 1992, Alameda County Waste Management Authority, Calif.

8. Waste Generation Study Performed by Gershman & Bratton, Inc., Mecklenburg County, N.C.

9. "The Waste Papers: Analysis and Discussion of the Potential for Salvage and Reuse of Construction Materials from Residential Demolition, Whole House Recycling Project," June 30, 1993, Report to Metro, Portland, Ore.

10. Composition of Waste Generated from Northridge Earthquake supplied by the City of Los Angeles, Calif.

11. "Building For Tomorrow: Environmental Compliance and Waste Reduction Workshop for the Construction Trades," Oakland, Calif., January 12, 1994.

III. BUILDING DEMOLITION

A. Introduction

This section provides a brief introduction to the types of structures likely to be encountered on a closing military base and a rudimentary understanding of the techniques available for deconstruction and demolition. It is hoped that those responsible for overseeing such projects and for preparing contracts and evaluating bids can use this information to understand the processes involved and choose bidders who are able to maximize reuse and recycling of C&D materials.

Recently developed demolition and recycling techniques are proving to be an efficient alternative to traditional and often cumbersome methods of demolition. The traditional methods of demolition were developed without regard to potential environmental impacts, and often the resulting debris ends up in uncontrolled disposal sites. In the past, building-demolition debris was taken to a municipal solid waste landfill. With increasing awareness of decreasing landfill capacity, many generators of building-demolition materials are recycling portions of this waste stream.

B. Demolition Stages

A demolition contractor must perform a variety of tasks in the process of demolishing a building. These tasks can be broadly grouped into several stages: placing a bid, obtaining a permit for demolition, clearing salvageable items, taking down the building, size-reducing and segregating materials, hauling materials from the building site, and backfilling the site to conform with existing codes.

1. Placing Bids And Obtaining Permits

For all city, county, and State-owned structures, and also for many private structures, the intention and invitation to bid for the demolition of a building is advertised, and the interested demolition contractors are asked to submit sealed bids for the demolition of the building. Bids are opened and the lowest bidder is usually awarded the job.

Most municipalities require that a permit be obtained for the demolition before a demolition contractor can start demolishing a structure. This permit serves several purposes: it assures that the owners have given permission to have the structure demolished; it provides a record of the demolition to the city, county, or State; and it provides a mechanism for city, county, or State inspection of all demolition to assure demolition building codes are being complied with.

2. Clearing Salvageable Items and Taking Down the Building

Clearing salvageable items usually precedes major demolition activities. Such items include piping, flooring, doors, windows, bathroom fixtures, kitchen fixtures, heaters, and lumber. The total value of these items may not compensate for the cost of removal and storage or delay in conversion of the site to new uses.

The actual demolition of the building can occur by a variety of methods described previously. The choice depends on various factors: type of construction, height, proximity of neighboring structures or rights of way, and salvage of structural materials. For example, wood-framed buildings are generally demolished by bulldozer or by hand demolition, while masonry or concrete buildings are more likely to be demolished by wrecking ball.

If salvage is planned, some degree of hand demolition will be necessary. For example, brick walls to be salvaged are cut into sections by hand labor and then pulled down by bulldozer, with rubber tires placed on the ground acting as cushions to limit the fracturing of the brick. The brick-wall sections are then transferred to some other convenient site and the bricks are broken away individually, and cleaned to be resold. Some heavy structural timbers can also be manually cut off from the structure and sold to contractors. This type of handling for salvage requires more labor than when no salvage is planned, but the additional cost of handling can be reduced if the efficiency of the cutting equipment is increased.

3. Size-Reducing and Segregating Materials

Size reduction is done in a variety of ways. For example, a bulldozer may be used to pick up and drop debris, especially concrete, to reduce its size. Other power tools can also be used to crush or to cut materials to smaller sizes. In choosing a particular piece of equipment, speed, noise, and dust are important considerations.

The incentives for segregating materials after demolition comes from the salvage value of the recovered materials and the difference in tipping fees for different materials in the debris.

4. Hauling Demolition Debris

Materials which are not reused on site are usually hauled away by dump trucks. The capacity of these trucks ranges from 15-60 cubic yards. Hauling costs should be considered when disposing of certain types of demolition wastes bound for recycling or disposal in a local landfill. The more demolition debris that can be recycled on site the lower both hauling and disposal costs will be for a demolition contractor.

5. Site Clearance

The last stage in the demolition of a structure is to prepare the site for future use. Contract specifications may require removal of all combustible materials such as lumber, paper, shingles, etc. Noncombustible materials may be allowed by local permitting auditors as backfill.

C. Structure Types

1. Wood Frame

Wood-frame construction is generally characterized by a concrete foundation, a wood frame built of a combination of light wood and heavy timber, and walls and floors also composed primarily of wood. In addition, the walls often contain fiberglass insulation; gypsum board; electrical conduit; and steel, lead, or copper plumbing. The roof often contains a significant amount of asphalt in the shingles and many of the floors will be tiled. Windows and doors contain glass, wood, and some metal in the frame and door handles. Wood-frame structures also contain a number of large, bulky items, such as furnaces, stoves, water heaters, radiators, bath tubs, and sinks, most of which will still be present in the structure at the time of demolition.

This type of building can be demolished entirely by hand, by machinery, or a combination of the two.

2. Wood and Masonry

Wood and masonry construction is used for many sizes and types of buildings, and is the second most common type of construction. Wood is typically found in floors, walls, and structural members. Walls of the building are most often composed of brick and mortar or cinder block and mortar; structural framework may be composed of any combination of reinforced concrete, brick, mortar, and wood. Commercial and industrial buildings may contain considerably larger amounts of metals and unusual items, such as elevators and heavy machinery. These items must be removed at the time of demolition, and may enter the stream of recycled materials as scrap metal or be sold for their original use.

3. Semifireproof and Fireproof

Buildings of fireproof and semifireproof construction exhibit uniformity in their basic design. Structural members consist of concrete-encased structural steel, both for the outer frame of the building and for the floor and roof. The floors of the building are made of steel-reinforced concrete, and the walls are often also made of steel-reinforced concrete.

Except in the rare case of explosive demolition, the most important element in the demolition of a semifireproof or fireproof building is a large crane and a wrecking ball. This equipment can knock down walls with little difficulty, but a significant effort remains to remove the structural steel from the concrete. The concrete can be knocked from the steel with repetitive blows from a wrecking ball; however, this is often not economical.

Before concrete can be loaded onto a truck, it must be freed from an array of reinforcing bars holding it in place. This is accomplished with the help of a laborer and an acetylene torch. It takes less than a minute to cut through a reinforcing bar. Once free, the concrete can be immediately loaded on a truck, or first size-reduced by either dropping it with a crane or front-end loader, or leveling it out and driving over it a few times with a bulldozer.

D. Demolition Methods

Buildings can be brought down either piece by piece, as in hand demolition, more rapidly with heavy equipment, or all at once with explosive charges. In piece-by-piece wrecking, workers usually employ hand tools, either mechanical or thermal (e.g. acetylene cutting torch) to recover the maximum amount of reusable material. Heavy equipment, such as bulldozers and wrecking balls, is faster but yields less reusable material. Explosive demolition is very fast but yields a commingled pile that is expensive to separate. When evaluating the different demolition methods, one should be aware that higher initial costs (as in hand demolition) may be offset by sale of reusable materials whereas the need for timely demolition may drive the decision toward using faster heavy equipment or explosive demolition at the expense of fewer salvagable and reuseable materials.

More information on demolition methods can be found in Appendix B.

IV. CONTRACTING

Most salvage and demolition work is contracted. On a large project, the site owner will bring in a contractor to remove unwanted buildings and paved areas, tear out abandoned underground utilities and tanks, clear unwanted plant materials, and grade the property in preparation for redevelopment.

The Department of Defense has statutory and regulatory schemes under which it must operate when contracting. Most of their contracting will be controlled under various laws, including, but not limited to, 48 Code of Federal Regulations section 36.000 et seq. However, consideration of the following may be useful in conjunction with the applicable contracting legal requirements as well as to situations and entities to which such requirements do not apply. This information is by way of example of processes that have been employed in the past. Any contracting needed on a particular site should be reviewed through the organization entering into the contract.

A. Contracting Process

Most contracting processes are similar. The party redeveloping the parcel sends out a proposal soliciting interest in the demolition project. The solicitation defines the nature and extent of the work to be performed and asks qualified contractors to bid on the project. The responses are evaluated, balancing the contractor's qualifications and the bid price. Usually, the responses are scored using predefined selection criteria and a common score sheet. Both the selection criteria and the score sheet are included in the solicitation so that bidding parties can shape their responses to best meet the objectives of the proposal. The contract is then awarded to the contractor with the highest scored proposal. This approach, with minor variations, is the path most commonly used by public sector entities.

Another common approach selects a panel of qualified contractors based on proposal scores. Either a predetermined number of contractors with the highest scoring proposals or all those contractors whose proposals scored above a predefined minimum are selected. The party seeking the work is then free to negotiate the most favorable agreement terms possible before awarding a contract.

There are variations in the contracting process. For example many large private organizations may select contractors from a predetermined list of eligible candidates. However, the two concerns underlying all contracting mechanisms are whether the contractor can perform as promised and that total costs be minimized.

Sample contract language can be found in the appendices.

B. Commonly Used Contracting Approaches for Materials Recovery

1. Standard Contract Process

Organizations generally structure their contracts using boilerplate language from a standard model. The nature and extent of the work to be performed is usually described in a "scope of work" section of the document that is specific to the particular job in mind. The same language is also included in the bid solicitation.

Most demolition contracts do not contain special language requiring materials recovery. The degree to which a contractor who bids on a project considers materials recovery is left to the contractor’s own judgment and will be governed largely by the ability of his/her current operations to salvage materials and his/her ability to sell those materials to offset her project costs.

2. Contract, Then Negotiate for Recycling Component

An approach that has been tried recently in at least one base-conversion project is to negotiate for materials recovery after the contract has been awarded to the highest ranked bid. The contractor may be asked to prepare a waste management plan in which he/she details how maximum recovery of salvageable materials will be achieved. The party issuing the contract then reviews and approves that plan before site work can commence.

This approach gives an added measure of control over the traditional contracting process. However, its success depends largely on the willingness of the contractor to implement recovery options which he/she may not have contemplated when the job was bid and which could negatively impact the profit margin. Also, the contractor's negotiating position is very strong because he/she already has the winning bid. The burden is on the party awarding the contract to substantiate that going with another contractor is justified if they cannot agree to the first contractor's waste management plan.

3. Two-Step Approach: Deconstruction, then Demolition

A third approach divides demolition into two stages. The first stage is dedicated solely to recovering reusable building materials at the project site. There are various ways of approaching this stage, but generally, nonprofit entities or commercial salvage operators are given access to the site to recover materials that are of interest to them. Normally, this is done at no cost to the property owner. The second stage follows the traditional contracting pathway for demolition of the property.

This approach has been used successfully on smaller projects, usually in larger urban areas, where there are for profit and nonprofit entities that cater to a local demand for recycled building materials. As a rule, buildings targeted for deconstruction contain high-value features that can be easily recovered and readily reused. Typical salvageable materials include clean, defect-free wood beams and sheathing, tile roofing, and fixtures.

4. Contract with Recycling Preferences Based on Specified Performance Goals

This approach is built on the premise that the key to successful recovery and reuse is to make it part of the demolition contract. This means building a recycling component into the contract solicitation by specifying material recovery goals in the scope of work, and tailoring the score sheet to favor those contractors that can achieve high levels of recovery at competitive costs. The contractors are asked to describe, in detail, how they plan to achieve maximum recovery and reuse in their bid response. The firm's experience in salvaging reusable materials is weighed along with their commitment to meeting the recovery goals described in the bid solicitation. All else being equal, a proposal that can achieve greater recovery and reuse is favored over one that achieves a lesser amount.

This approach may have the greatest potential to encourage recycling on large redevelopment projects because it requires the bidders on the projects to compete amongst themselves to demonstrate how they will achieve maximum materials recovery. Yet the bidders remain free to decide how they will adjust their own business practices in response to local market conditions and meet the recovery goals for the project in a cost-effective fashion. Additionally, this approach can be easily integrated into a contracting mechanism that is already being used by an organization, it does not extend the timeline for the project, and the party issuing the contract is not required to develop special expertise or allocate staff to the recovery facets of the project.

V. END USES AND MARKETS

This section presents the possible end uses of materials recovered in deconstruction and demolition activities, which helps in the identification of facilities that would take the recovered materials.

Markets for specific construction and demolition (C&D) materials greatly influence reuse and recycling activities. Recycling facilities will use their resources to efficiently recover the material if reasonable profits can be expected from the sale of the recycled materials. On the other hand, the material may not be salvaged or recycled if the commodity does not command a high enough price in the market.

There are several site specific factors that can affect the economic viability of recovering materials from a demolition or deconstruction project. The most desirable option, and most cost effective, is to reuse the recovered materials on site. The extent to which this practice can be employed is dictated by the materials recovered, the potential available end uses, and future plans for the site.

If recovered materials have to be transported to local markets, the cost of the transportation can become a significant factor when determining the economic viability of the project. It makes sense to minimize the number of haul trips and distance to local markets to the as much as possible.

The final factor to consider when bringing recovered materials to market, is the amount of material the local market can sustain. Flooding a market with too much material at one time will drive local prices down and reduce potential income from the sale of recovered materials. Therefore, additional storage needs may have to be considered to avoid market saturation.

A. Processing

The processing strategies employed to recover or reuse C&D materials depends on the composition of the C&D materials and the end uses for the recovered materials. Composition refers to the types of materials and the form in which they are received by the processors, either clean or mixed.

For maximum recovery value, C&D materials should be presorted as much as possible by depositing loads of similar materials in segregated areas, picking with front-end loaders, etc. Bulky items such as large pieces of rubble or wood are often presorted. With mixed loads, it is important to evaluate the cost of separation versus disposal. Certain loads may be so contaminated or mixed that separation may not be economical when compared to disposal.

B. End Uses

Presented below are the end uses for the C&D materials that are commonly recovered. A summary of these end uses is presented in Table 1.

1. Asphalt

Most asphalt waste comes from repaving projects which removes the top layer of the old asphalt before replacing it with new asphalt. Typically, 10 to 15 percent of the old asphalt can be incorporated in new asphalt pavement. In general, virgin asphalt is stronger and more durable than recycled asphalt. Old asphalt has been degraded by weathering and sunlight. These weaknesses are carried into the recycled paving material when processed.

The “Greenbook” (Standard Specifications for Public Works Construction), which is used by the City and County of Los Angeles and 200 other local governments and agencies in Southern California, allows for 15 percent of reclaimed asphalt pavement (RAP) in the virgin mix.

Asphalt roofing scrap, after mechanical reduction to sand-grain size particles, can be used as an additive in hot-mix asphalt. The high asphalt content of asphalt-based roofing materials enhances the engineering properties of asphalt pavement. Asphalt-based roofing can also be processed to produce a cold patch material. This patch product can be used to fill potholes and patch roadways without the handling and processing problems associated with hot-patch products. The scrap can also be ground and used in aggregate base and as temporary road base.

2. Recycled Aggregate

Recycled aggregate comes primarily from concrete and asphalt from road rehabilitation and maintenance, demolition, and leftover batches of asphalt and concrete.

The primary market for recycled aggregate is as aggregate base and sub-base in road projects. Other uses include gravel roads and surfacing, and fill for utility trenches. Local governments can help promote markets for recycled aggregate because they purchase large amounts of aggregate. Communities that have taken steps promoting recycled aggregate include:

a) Los Angeles

The City of Los Angeles requires that road base in all city projects include "crushed miscellaneous base (CMB) with 100 percent recycled asphalt, concrete, and other inerts, except when site conditions or standards require other specifications."

b) Modesto

The City of Modesto has a purchasing practice for on-site street recycling that includes recycled aggregate.

3. Wood

Uses for recycled wood include feedstock for engineered woods, landscaping mulch, soil conditioner, animal bedding, compost additive, sewage sludge bulking medium, and boiler fuel. The end use of the wood waste determines the degree of processing (screening and separating) needed.

Although the largest market for recycled wood is as fuel for biomass facilities and as compost, a highly desirable option for wood waste management is reuse. Nonstructural, architectural, and ornamental pieces can be reused if the pieces are in good condition. If structurally sound pieces of lumber are being salvaged with the intent to reuse them as structural elements in new buildings, the pieces would need to be recertified by a lumber inspector.

Wood waste can also be used as a feedstock for engineered woods such as particle board, masonite, laminated wood, and plywood.

4. Drywall

Gypsum recovered from drywall processing can be used as a soil amendment or as a feedstock blend to drywall manufacturing.

5. Metal

Several metal types are recovered from C&D debris. Aluminum and copper are considered precious commodities. Steel and other ferrous items are also readily recyclable and are being sent to scrap metal dealers.

TABLE 1

End Use Markets for C&D Waste

Waste Type	**End Use**
1. Asphalt	Mixed with recyclable asphalt for roads
2. Asphalt roofing shingles	Asphalt, pothole patch, aggregate base
3. Concrete and asphalt	Aggregate base, sub-base, fill
4. Metal - Aluminum - Appliances/white goods - Brass - Copper - Ferrous pipes, roofing, flashing, etc. - Steel	Scrap metal dealers
5. Wood - Untreated - Treated	- Chipped for fuel, landscaping, compost bulking, animal bedding, manufactured building - May be reused for landscaping or other needing treated wood
6. Other C&D waste - Brick - Glass - Gypsum/drywall - Plastic - Porcelain - Topsoil - Used corrugated cardboard - Carpet	- Masonry, landscaping, ornamental stone - Recycled into fiberglass insulation, salvaged - Chipped into raw material, soil amendment - Chipped/shredded and used to make insulation, carpets, lumber - Reused if in good condition, ground and mixed concrete, sub-base, aggregate - Soil, soil conditioner, landscaping, landfill cover - Fuel pellets, recycled into new cardboard - Sent to carpet recycling program

C. Reuse

Hand demolition, compared with the use of heavy machinery, will yield more lumber and other architectural fixtures that can be salvaged for reuse.

Older or unique structures may have valuable materials such as wooden fixtures, moldings, casings, sashes, framing, and timbers for reuse or remilling. These structures are more likely to contain structural components worthy of remilling (for both structural and ornamental applications) and fixtures of interest.

Large timbers and dimensional lumber from deconstruction can be reused or recut for other construction projects. In many cases the lumber may need to be regraded by a certified grader if it is used for anything other than ornamental purposes.

Other items such as doors or windows in usable condition can be sent to recycled building materials stores that accept and sell reuseable home and building furnishings and fixtures. Some of the facilities identified are listed below.

Architectural Salvage of Santa Barbara
726 Anacapa
Santa Barbara, CA 93101
(805)965-2446

Beyond Waste
3262 Wilder Road
Santa Rosa, CA 95407
(707) 792-2555

Building Materials Distributors
1708 Cactus Road
San Diego, CA 92173
(619) 661-7181

Building Resources Materials Reuse
701 Amador St.
San Francisco, CA 94124
(415) 285-7814

Ohmega Salvage
2407 San Pablo Ave.
Berkeley, CA 94702
(510) 843-7368

Urban Ore, Inc.
1333 Sixth St.
Berkeley, CA 94710
(510) 559-4460

VI. CASE STUDY

PRESIDIO OF SAN FRANCISCO: BUILDING 901

A. Background

The Presidio of San Francisco is located on the northern point of the San Francisco Peninsula at the South end of the Golden Gate Bridge, and is dissected by Routes 101 and 1. This former military post is now part of the Golden Gate National Park. The lands that constitute this national park extend north to Tomales Bay in Marin County and south to the San Francisco watershed lands in San Mateo. The park encompasses 73,000 acres of land and water.

The Presidio of San Francisco was transferred from the U.S. Army to the National Park Service in 1995. It encompasses 1,480 acres and contains 870 buildings, a research facility, a golf course, and a national cemetery. Of the 870 buildings on site (representing over 6.2 million ft2), 570 have landmark status. The remaining 200 buildings are slated for demolition. The current plan is to demolish 43 of the 200 buildings this year. This first phase of demolition will address the buildings around Crissy Field.

The closure and redevelopment plan for the Presidio intends for the area to be a working laboratory to create models of environmental sustainability. These models could then be transferred worldwide. Under these guidelines, there was recycling language incorporated into the overall demolition contract for the buildings on site. However, the contract did not have high percentage requirements for recycling and did not differentiate reuse, salvaging, and other high order uses from recycling or mulching materials. The mechanical demolition proposed for the first stage of demolition would allow for the minimum recovery but precluded language that gave preference to salvaging the materials for high order uses.

After much debate and lobbying from various interested parties, two buildings were pulled out of the greater demolition contract. Those two structures were buildings 283 and 901 which were located at opposite ends of Crissy Field. The larger of the wood buildings, 283, was a two story timber frame structure that served as a machine shop, storage, and office building. This building was dismantled by the general contractor, South Bay Maintenance, Inc. The other building pulled from the larger contract, building 901, will be the focus of this case study.

The proposed demolition of building 901 would be done in a fashion that would salvage and recycle as much materials as possible. As a result, the demolition would involve a great deal of hand dismantling and salvaging of materials and will serve as an excellent basis for case studies.

B. Building 901 Overview

Building 901 is located on the west side of Crissy Field. It is a one-story wood frame building with floor dimensions of approximately 60' x 135'. It was constructed in 1942 as a "temporary" wartime structure. The building served as a warehouse with office space added to a portion of the interior at a later date. The building was constructed almost entirely of wood, with wood siding, wood flooring on concrete supports, and wood slat roofing boards covered with a recent reroof of asphalt shingles.

The deconstruction and salvaging of materials was performed by a consortium of representatives from three salvaging groups. Participants in the hand deconstruction activities included: Beyond Waste, a Sonoma based deconstruction partnership, whose business manager is Pavitra Crimmel; San Francisco Community Recyclers, a non-profit organization involved in recycling services and education in the conservation of resources directed by Kevin Drew; and Wood Resource Efficiency Network, an Oregon based conservation research endeavor coordinated by Phil Kreitner.

The intent of the 901 project was show the amount of materials that can be salvaged using soft demolition techniques, while performing the operation at costs competitive with traditional demolition operations. The materials will be salvaged to the greatest extent possible and sold to the group(s) with the highest bids.

C. Site Visits

The following chronology of the deconstruction of building 901 is based primarily on four site visits to this project by the staff of the California Integrated Waste Management Board (CIWMB). The observations and conclusions noted by staff are as follows:

1. April 4, 1996 Site Visit

Staff from CIWMB first visited the site of building 901 on April 4, 1996 to document the deconstruction and salvaging techniques used on the building. At this point, remediation for the removal of lead-based paint and asbestos had already occurred. Hazardous materials removal by qualified professionals is necessary prior to commencement of any demolition activities.

This first visit revealed that deconstruction activities were already well underway. As shown in the adjacent illustration, some of the siding and the majority of the roofing material was already removed, revealing the roof joists. The majority of interior sheeting had also been removed.

Although the siding had been scraped to remove loose lead-based paint, the majority of exterior paint remained on the wood. In the past, demolition operators have questioned the logic of scraping and removing loose paint only to have far more paint loosened during disassembly of the structure. No resolution to this issue has yet been developed.

The siding on building consisted of tongue-and-groove (T&G) redwood. In order to reuse the painted siding, which is coated with lead based paint, the boards will have to be turned over, exposing the unpainted side, or the wood will have to be remilled, adding to the cost of the final product.

Other exposed sections of the building revealed that the roof rafters were 14 and 21', 2" x 6" lumber tied together to span the entire length to the ridge pole of the building.

The flooring was still intact during this visit, but the crew expected it would be difficult to remove because it was constructed of 2" x 8" T&G that was toe-nailed down. This makes it very difficult to remove the boards without splintering the wood. The floor was supported by 2" x 12" joists and the roof was supported by 6" x 6" posts throughout the structure as illustrated in the adjacent picture.

The crew was carefully recovering as much lumber as possible from this structure. The economics of this project have been modified somewhat by the fact that the entire job falls under federal prevailing wages as dictated by the Davis-Bacon Act. As a result, the laborers, by law, must be paid federal prevailing wages on site. This translates to about \$25–\$35/hr which is above what is normally paid to salvagers on a non-federal deconstruction job.

1. *4/4/96: 6"x 6" supporting posts throughout Bldg 901.*

2. *4/4/96: Building 901. Roofing material removed exposing rafters.*

The crew was given four weeks to dismantle the building. The work was progressing well and they anticipated completing the job in three weeks.

3. *4/12/96: Crew is in the process of removing rafters.*

At this point in the deconstruction, wood was removed and stacked with similar dimension and type lumber. The wood that was denailed was stacked and looked ready for sale.

The windows were removed in their casings and were to be sold as whole units. Older wooden frame windows sell for $5 to $20 depending on the size and condition. There seems to be a fair demand in the San Francisco Bay area for this type of window, mostly from local artists, and cabinet makers, or for replacements in many of the older buildings in the area.

The exposed interior walls revealed the difficulty in removing the drywall. The abundance of nails and remaining adhesives indicated that this was a very labor-intensive job. These aspects of a job are not always obvious at first inspection.

The studs that were recovered were generally grade 1 and clear. The wood is also quite dense. This is an extremely high quality wood considering that most of the studs pulled so far are nonstructural. When there are knots in the wood, they are quite large, indicating that they came from old growth stock. These knotty elements would not pass today's grading standards for construction lumber. Some of the framing material pulled from the interior is redwood. This came out of one of the offices added to the building interior.

Phil Kreitner, of the Wood Resource Efficiency Network, indicated that he hoped to get about $1/board foot (bf) for the wood. This is comparable to prices for lumber found at a local home improvement center. In order to demand this premium price, the materials will need to be marketed as old growth stock, which is denser and stronger than today's lumber, or associated with the Presidio to inform the buying public that this material differs from normal lumber.

2. April 12, 1996 Site Visit

The deconstruction had progressed significantly from eight days earlier. The building was stripped down to the bare framing material. The floor boards remained intact at this juncture of the project. Most of the wood that was removed was denailed and stacked according to size, type, and shape in neat piles on the surrounding lot.

4. *Alternate view with Golden Gate Bridge in background as a reference point.*

The recovery of the clean lumber is quite labor intensive due to the inordinate amount of nails and fasteners that were used to adhere the redwood siding to the building. In addition to removing the wood without damaging it, a great deal of time must be spent removing these fasteners.

One advantage that this particular project presents is that the site of building 901 is serving as an ad-hoc lumber yard. The consortium will try to maximize this aspect of the job and sell as much material on site to the public which will reduce transportation costs. Any remaining lumber will be divided between San Francisco Community Recyclers, Beyond Waste, and Wood Resource Efficiency Network to be sold at a later date. The crew expected to have the building totally dismantled within another week.

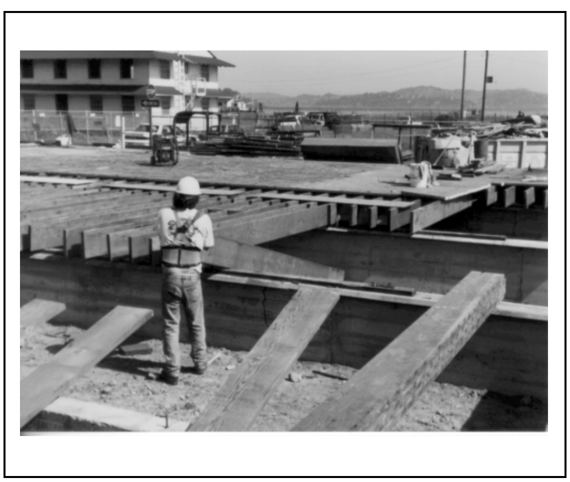
3. April 24, 1996 Site Visit

Again, the project has progressed significantly since staff's last visit, in spite of rain that reduced the number or working days.

The building had been dismantled to a point where it no longer is visible from any distance. All the framing has been removed, denailed, and neatly stacked on the surrounding lot. The wood was sorted by size and type. The majority of structural wood consisted of douglas fir studs of grade one or structural select with some redwood studs coming from the walls of an interior office. A few grade two studs were found in the interior walls. The ceiling studs and exterior siding were redwood and some pine was recovered from the wall planks and a few studs.

The crew was removing the remaining portions of the flooring during this site visit. Of the original floor, approximately one-third of the floor joists remained and one-fourth of the T&G floor boards were still in place. The concrete walls that support the floor joists are about 6 inches wide, 2 feet tall, 12 feet apart, and run the length of the building.

As anticipated, removal of the floor boards was labor intensive because each board was toe-



5. *Crew remove joists after T&G floor is pulled up.*

nailed in. To expedite removal without damaging the lumber, the crew ran electric reciprocating saws, powered by gas generators, between the boards and the floor joists to cut the nails. The boards were then lifted using a tool that looks like a horseshoe welded at a right angle to a pry bar (as seen in the adjoining photo). The flooring itself is 2" x 8" stock running in lengths of 12' to 24'. The crew was unsure of the type of wood that made up the flooring. It was guessed at the time, that the flooring may have been sugar pine or cedar, and was later determined to be Port Orford Cedar.

6. *4/24/96-Lot starts to look like a lumberyard.*

7. *4/24/96: Crew cuts nails with electric saws and pries up floor boards.*

The remaining third of the flooring was covered with mastic residue from the removal of asbestos tiles that covered the office area inside the building. To reuse the wood that made up this portion of the floor, the boards will have to be turned over, exposing the unfinished side, or remilled.

Phil Kreitner informed staff on this visit that an additional 4000 board feet (bf) of decking was sold on site for $1/bf.

The work completed thus far had taken 15 working days. The crew felt confident that the job would be completed close to the original estimate of four weeks.

4. May 10, 1996 Site Visit

CIWMB staff did not return to the Presidio until May 10. The final disassembly and salvaging of building 901 occurred some time between April 24 and May 10. The only evidence that a building existed was the vacant lot and stacks of lumber still remaining on site (illustrated in the adjoining photo).

8. *5/10/96: Nothing but a vacant lot and a view of the Golden Gate Bridge.*

9. *The remaining lumber will be sold off site*.

As the photo of the vacant lot above illustrates, the concrete walls supporting the building were broken up and removed. This portion of the project was performed by a separate contractor.

Approximately half the lumber recovered from building 901 was sold on site. The remaining lumber was divided between San Francisco Community Recyclers, Beyond Waste, and Wood Resource Efficiency Network to be used or sold at those sites.

D. Materials Recovered

On 9/1/96, a final summary was made of the amounts of wood recovered from Building 901. The information is contained in Table 2.

E. Project Economics

Of the 65,295 bf of wood recovered, approximately half (34,355 bf) was sold on site with an additional 1,545 bf donated. The on site sale of the wood generated $30,155. The prices for the wood ranged between $0.25/bf for roof planking to $1.50/bf for the douglas fir flooring. The majority of wood sold for around $1.00/bf. The remaining wood was divided among the members of the consortium.

Table 2 shows that the consortium contracted to dismantle building 901 was able to recover 85 percent of the wood fraction of the materials generated. It was estimated that 15 percent of the wood was found to be unusable or degraded to recycling quality during the dismantling of the building.

It was estimated that it took approximately 1000 man-hours to dismantle building 901. This resulted in an on-site labor cost of $33,053. There were additional logistical costs of equipment hauling and removal of the concrete footer of $11,983 and administrative costs totaling $12,604. These costs resulted in a total expenditure for the project, not including hazardous materials remediation, of $57,640.

Table 2

Member/Species	Dimension	Volume	Volume Recovered (% Recovered)
Roof Plank (T&G)/Pine-Fir	1" x 8" x 10'-15' 1" x 12" x 10'-15'	4800 bf 4800 bf	1200 bf (25%) 2400 bf (50%)
Wall Plank /Ponderosa Pine	1" x 10" x 6'-10' 1" x 12" x 6'-16'	1200 bf 2600 bf	1100 bf (90%) 2500 bf (95%)
LDF Wall, Peak Liner/Unk.	1" x 4' x 8'	300 sheets	0 (0%)
Firring/Port Orford Cedar	1" x 2" x 6'-10'	200 bf	10 bf (5%)
Interior Ply/ Doug Fir	0.25" x 4 'x 8' 0.5" x 4 'x 8'	55 sheets 8 sheets	52 sheets (95%) 8 sheets (100%)
Non-Struct. Framing/Doug Fir	2" x 4" x 8'-12'	500 bf	450 bf (90%)
Ridge, Purlin /Doug Fir	2" x 10" x 20'	2350 bf	1700 bf (70%)
Rafter/Doug Fir	2" x 8" x 14' 2" x 8" x 20'	2800 bf 4000 bf	2670 bf (95%) 3800 bf (95%)
Cross-tie,Stud/ Doug Fir	2" x 8" x 16'	2000 bf	1950 bf (95%)
Post/Doug Fir	6" x 6" x 13' 6" x 6" x 16'	1400 bf 1700 bf	1400 bf (100%) 1680 bf (99%)
Brace/Doug Fir	2" x 6" x 12'	3000 bf	2700 bf (90%)
Stud, Ceiling Joist/Fir-Pine	2" x 6" x 10'	1500 bf	1350 bf (90%)
Stud,Ceiling Joist/Redwood	2" x 6" x 8'	600 bf	540 bf (90%)
Siding/Redwood	1" x 6" x 6'-20'	1600 bf	1200 bf (75%)
Ext. Deck,Joist, Facia/ S-P-F	2" x 4" x 6'-14' 2" x 12" x 14'	500 bf 1100 bf	0 bf (0%) 1080 bf (99%)
Flooring (T&G)/ Doug Fir	1" x 4" x 3'	45 bf	45 bf (100%)
Flooring(T&G)/ Port Orford Cedar	2" x 8" x 12'-24'	15,600 bf	15,500 bf (99%)
Floor Joist/ Doug Fir	2" x 12" x 14'	21,400 bf	21,300 bf (99%)
Sill/ Pine	2" x 6" x 14'	800 bf	720 bf (90%)
Total		75,295 bf	65,295 bf (87%)

Information contained in Table 2 was provided by San Francisco Community Recyclers and Wood Resource Efficiency Network.

Income from the project emanated from several sources. $16,800 came from the greater demolition contract give-back. This was the savings estimated by the general contractor for not having to demolish the building. An additional $15,000 was supplemented by the National Park Service to foster the hand deconstruction project and help develop future projects of this kind. Sale of the lumber on-site generated an additional $30,155. This results in a net income of $61,955 and a net profit to date of approximately$4,315. It was estimated that the value of the unsold lumber recovered from building 901 was approximately $13,500. If the recovered lumber from this project is sold for the estimated value, the net profit from the deconstruction of building 901 could be close to $20,000.

F. Conclusions

Each deconstruction project will be unique and have to be evaluated for the materials that will be generated, the local markets, labor costs, time frames, and overall feasibility. However, this project has yielded some general conclusions that can be applied to any proposed project.

1. Cost/Benefit

This project clearly shows that hand deconstruction can be performed at rates competitive with mechanized demolition while recovering valuable material, preserving natural resources, and conserving available landfill space. Depending on the structure and situation, hand deconstruction and salvaging can be more economical. This particular building yielded a great deal of high quality, clear, old-growth wood, which is not readily available and will always be in demand. As such, the project was profitable even at prevailing federal wages. If this project had taken place on a non-federal site, or ownership had been deemed to a non-federal entity, the wages paid to the workers would probably be closer to private laborer wages. However, the cost/benefit analysis is somewhat skewed by the National Park Service supplement. It is also difficult to say whether the demolition contract give-back is an accurate estimate of the cost to demolish the structure. Furthermore, the amount sold and price obtained for the remaining lumber recovered from the building would ultimately dictate the final profit of the project regardless of the supplement provided by the National Park Service.

2. Worker Experience

The crew's ability to salvage material without destroying it in a timely fashion enabled the project to achieve a high recovery rate and in turn, maintain its cost effectiveness. If a project is being proposed that involves hand deconstruction and salvaging, it is imperative that professionals with salvaging experience be sought out. Experienced demolition operators are not always the best choice for salvage operations. If a project is to achieve a high rate of recovery, the operators chosen must have knowledge and/or experience in the non-destructive recovery of building materials, not just demolition experience.

3. Define Rate of Recovery

When proposing a job with the intent to reuse or recycle a high percentage of materials generated, a minimum rate of recovery should be specified and terms such as "recover" must be well defined. This project salvaged a high percentage of lumber for reuse. Of the 15 percent of the wood not recovered, a portion was being ground by wood processors. If terms are not defined in the contract, the grinding of wood waste can be defined as recycling and meet goals stated in the contract without meeting the intent of the project. Define terms such as recycle and reuse to ensure that intended goals are met and that there is a level playing field for contractors bidding the project.

4. Time Frames

Deconstruction or "soft demolition" techniques generally take longer than mechanized demolition operations. In order to salvage building materials, additional time is usually needed. This must be accounted for when planning a salvage operation in lieu of a mechanized demolition operation.

5. Storage Needs

Additional storage areas may be necessary if high percentages of materials will be recovered. In the case of building 901, the surrounding lot was fenced off and served as an ad-hoc lumber yard, which enabled the crew to sort and stack material according to size and type. This, in turn, fostered the on site sale of over half the lumber recovered from the building. Beyond generating immediate revenues and allowing the local community to purchase desirable materials, it reduced shipping costs.

6. Project Summary

There were two factors, specific to this project, had they been altered, could have influenced the overall profitability of the project. The first factor involves contract negotiations. The overall demolition contract was amended to include the deconstruction of building 901. Since this aspect was added to the contract after the fact, it is reasonable to assume that the proponents of the deconstruction project were not negotiating from a position of strength. As such, they may not have been able to negotiate the most economically desirable contract. However, it is difficult to determine how great an influence this had on the final agreement. Regardless, it is safe to say that it is far better to incorporate all reuse and salvaging aspects of a project into the contract in the beginning rather than reopen the contract to negotiations later in the process.

The second site specific factor that may have influenced the overall economics of this project involved assessment of the value of the recovered materials. In general, the consortium was quite knowledgeable about local markets and the materials that they recovered. However, in retrospect, they did indicate that the Port Orford Cedar recovered from the flooring could have probably been sold at a higher price due to it scarcity. It is inconclusive how high a price the market would bear for a material such as this and it is probably best to file this aspect under lessons learned.

It should also be noted that remediation of asbestos and lead based paint occurred prior to deconstruction and was not part of the economic analysis. Any project being proposed should consider any additional costs associated with the remediation of hazardous materials. In general, the military will remediate materials that are hazardous and that have an exposure pathway from any structures prior to conveyance. However, this may not address all asbestos and lead based paint that may be exposed during a deconstruction or demolition operation. Only a site specific analysis could determine if costs for remediation of hazardous materials at a deconstruction project would differ significantly from remediation costs at a mechanized demolition project.

The site-specific issues discussed above, as well as the general issues discussed in the previous sections, may need to be considered when evaluating the economic benefits of choosing deconstruction and salvaging of a structure over mechanized demolition. However, if thoughtfully planned, a deconstruction project can yield significant income (as illustrated in Table 2), as well as save disposal costs, virgin resources, and valuable landfill space.

This case study would not have been possible without the information and ongoing assistance provided by representatives from the National Park Service, Beyond Waste, San Francisco Community Recyclers, and Wood Resource Efficiency Network.

VII. APPENDICES

A. Demolition Methods

1. Introduction

This section presents the most common methods used to demolish structures.

2. Manual Wrecking

Manual wrecking employs wedges, bars, picks, and sledge hammers to break down a structure piece by piece. The mechanics are straightforward. Because the process is slow, it offers the benefit of precise demolition of members and therefore greater opportunity for reuse or recycling. In fact, all bricks and most timbers are reclaimed manually. The removal of metal piping, windows, and doors for salvage also has to be done manually in order to make them marketable. However, manual wrecking of structural members such as beams and columns can be slow and costly.

3. Mechanical Wrecking

Power tools are necessary for the efficient demolition of structural members made of heavy timber and reinforced concrete. There are primarily three main classes of mechanical tools using different mechanical actions. The following tools use impact or hammering actions: pneumatic pick, hydraulic hammer, forge hammer, crane, and clamshell bucket. The second group of tools uses static-pressure action: bulldozer, hawser, burster, and column crusher. And lastly, these tools use cutting action: diamond saw, ripper, and water jet. Except for the water jet, which is still in the experimental stages for cutting concrete, all the equipment mentioned above is commercially available.

a) Tools Using Impact

Impact action is used for demolishing concrete and masonry structures. Picks and hammers pneumatically or hydraulically driven are commonplace in demolition. The pick is a hand-held tool; the hammer is often mounted on a crawler or a backhoe. The crane with a wrecking ball or clamshell bucket, and a relatively new development—the guided drop hammer—use impact action and are driven by gravity.

In evaluating the efficiency of these tools in demolition, one has to look at the mechanisms with which they break up materials. The pneumatic hammer uses a tensile-splitting mechanism by which a wedge-shaped hole is formed on impact, followed by crack initiation and propagation from the wedge on repeated shocks. Efficiency of this method is extremely low when used on reinforced concrete or on high-strength concrete, where the pneumatic pick method is more efficient.

Pneumatic picks do not always cause good separation of reinforcing steel from the concrete because the cracks are not necessarily oriented along the concrete-steel interfaces. Picks driven by air compressors are noisy and mufflers are increasingly required by OSHA regulations, city ordinances, and/or job specifications.

Hammers and wrecking balls (or clamshell buckets) use a punching/crushing mechanism by which materials shear apart on the weakest planes from repeated blows. There is a greater chance for concrete and steel separation than when pneumatic picks alone are used because the bonding between steel and concrete is comparatively weak in the matrix. This means that heavily reinforced concrete is not as serious a problem for these tools as for the pneumatic picks. The major disadvantage of these tools is the need for considerable space for their operation.

Clamshell buckets are also used to bite off the tops of walls and other structures and to lower the materials to the ground. This method can be used where there is little clearance around the building.

Pneumatic picks and drop hammers are generally operated downward against horizontal surfaces. The hydraulic hammer is a part of a system that incorporates a hydraulically supported boom on a vehicle, which can be operated both vertically and horizontally. The action of balls and buckets is either a vertical drop or a sideways swing. They are attached to cables hoisted by cranes. For efficient control of the swinging motion, a “tag master,” using a cable drum and clutch mechanism, is used. A clamshell bucket is sometimes used in place of the wrecking ball because of the impact shearing action of its teeth and its ability to more readily sort the materials for reclamation purposes.

b) Tools Using Static-Pressure Action

The typical machine that uses static-pressure actions for demolition is a bulldozer. This is particularly popular for pushing down single-story, wood-framed structures. Some contractors mount grappling booms on the buckets of the bulldozer so that upper levels can also be reached.

A hawser is a steel cable wrapped around the structure to be demolished and tied to a bulldozer at its ends. The bulldozer pulls down the structure by static pressure.

A hydraulic burster bursts concrete apart in a predrilled hole. It uses the radial push of a splitting wedge containing a plug and two narrow-angled wedges to develop cracks at the top of the predrilled hole.

A column crusher is a specialized piece of equipment in which its action is like a pair of teeth chewing on the concrete column bit by bit. It can crush concrete in place and has the advantages of quiet and vibration-free operation.

c) Tools Using Cutting Action

This class of tools is not used as often as the previous ones. It is used primarily for concrete demolition. The cutting action generates a free edge or boundary in concrete so that only a specific portion of the material is removed.

The principal cutting device for concrete is the diamond saw, which is expensive but precise. It has difficulty in cutting thick sections and uneven surfaces.

The ripper is a bulldozer or grader equipped with ripping tines. It is commonly used to cut thin and lightly reinforced concrete sections on highways.

Water jet cutting systems use a thin stream of water at high pressure through a hand-held lance fitted with special nozzles. To cut concrete, a water pressure of about 10,000 psi is used. A jet with a pressure of 150,000 psi can cut through steel. The advantages of the water jet are its maneuverability and its high-quality cutting. Water jets can also be used to cut wood.

4. Thermal Wrecking

Thermal demolition is defined as the use of an oxy-acetylene torch to cut steel or the use of a thermic lance to cut reinforced concrete. Oxy-acetylene cutting is a well-known process. The thermic lance is a well-developed process used mainly in European countries. It employs the heat generated by the burning of metal in oxygen to melt concrete. The main advantages of the thermic lances are noiselessness, quick operation, and easy assembly at the site. The primary disadvantages are smoke and fume generation, which can be a fire hazard. The cost is high, but may be lower than alternatives for many special applications.

5. Explosive Wrecking

Explosive demolition is usually cheaper than manual, mechanical or thermal demolition. The project duration of demolition, including planning, wrecking, and site clearance, is also shorter than other methods. The primary drawback of explosive demolition is the lack of enough open space around many buildings.

When done properly by experienced engineers, explosive demolition is a very efficient process. Explosives can wreck both steel and concrete structures. It can also perform precise cutting. The mechanism by which explosives break material is tensile splitting, and is accomplished by the generation of rapidly expanding gasses. In breaking reinforced concrete, proper arrangement can separate the concrete completely from the reinforcement to make a very clean steel and concrete separation.

B. Processing Techniques

1. Introduction

This section is presented to give base closure groups responsible for demolition projects an overview of equipment and processing techniques involved in structure demolition and materials recovery. Although it is not a comprehensive and detailed discussion of materials recovery equipment and processes, it is intended that this information can be used by responsible parties to make more informed decisions during the processes of planning and contracting for the removal of structures at closing military bases.

2. General

The traditional means of C&D recovery include salvaging of C&D materials at the job site by contractors. These materials can be sold and provide additional revenues to contractors. "Dump-and-pick" is also an old practice for the recovery of a limited amount of material. This practice reduces the bulkiness of C&D material by simply dumping the material on the ground and running over it with heavy equipment. Recyclable materials are then hand picked from the rubble.

For clean, sorted loads of debris, primary reduction equipment alone can provide quality end products. Primary reduction equipment includes jaw, cone, and impact crushers; hammermills; and stump grinders.

In C&D processing, there are two basic processing strategies: sort and separate, then crush and reduce; and crush and reduce, then sort and separate.

Determining which processing strategy to use for a specific project depends on the nature of the mixed material. For fairly clean loads consisting mainly of rubble or wood, it may be acceptable to crush and reduce the material loads before sorting and separating. For operations which attempt to process mixed loads of C&D materials, more equipment or manual sorting may be needed. It is important to sort and separate commingled C&D debris before crushing. This debris may contain paint or asbestos that could be fragmented if crushed which would then contaminate large amounts of C&D materials.

After bulky materials are removed from mixed loads, building demolition processors have found it effective to separate the soil, rocks, and concrete before hand picking recyclables. Trommels and disc screens usually are used to separate soil and rock, with additional screening and separation equipment added if needed. Hand pickers then recover the various recyclables on a sorting platform.

3. Specific C&D Materials

a) Wood Processing

C&D wood waste can be processed in different manners depending on the intended end use. It can be chipped with a mobile chipper or grinder at the site where the material is produced, it can be hauled to a processing facility that accepts and processes wood waste only or it can be delivered to a full-service processing facility where multiple types of C&D wastes are processed.

Nonwood materials are first separated from the waste. If the material is not source-separated, some facilities use flotation tanks to separate wood from nonwood material. Manual sorting may also be necessary. The material is then conveyed past a magnet to remove metals such as hangers, nails, and staples. Conveyors then take the material to a hammermill where small, uniform wood chips are produced.

After the hammermill, the material passes another magnet for further removal of any remaining ferrous metals. It is then fed onto a vibrating screen that separates oversized materials from undersized materials.

Depending on the end use for these streams of wood material, additional size reduction and screening may still be required.

b) Asphalt Processing into New Asphalt

Processing of asphalt can be done on site during major road repair jobs, or can be sent to an off-site processing facility. With on-site processing, mobile crushing units are used to reprocess asphalt into new asphalt. The most common technique is to add 15 percent reclaimed asphalt pavement (RAP) into new asphalt (see Appendix for details of recycling techniques).

At a processing plant, used asphalt is crushed into smaller, more uniformly sized pieces. Magnets are used after the crusher to separate ferrous metals. The crushed material then passes through a series of screens that size the material to determine its grade. Oversized materials are sent back to the crusher and run through the system again. In addition, a washing system may be used to meet the specifications required for different grades of material. Crushed AC is then conveyed to a pug mill where new asphalt emulsion is added as a binder to produce new asphalt.

c) Concrete and Asphalt Processing into Aggregate

Concrete and asphalt can be processed into aggregate using portable equipment that can be set up on site for immediate use of the recycled aggregate or it can be sent to an off-site processing facility.

Concrete and asphalt is broken into 6-inch pieces with a jaw, cone, or impact crusher, then conveyed to a large electromagnet to remove ferrous metals such as rebar used as reinforcement in concrete. The crushed material, referred to as aggregate, then passes through a series of screens to separate the material by size and into grades.

4. Equipment

In C&D debris processing, equipment can be grouped into three main types: conveying, crushing/reducing, and screening/separating.

a) Conveying Equipment

Conveyors transfer materials from one location to another. The most common type of conveying equipment used to process C&D is the belt conveyor which consist of a strip of belting material that is looped around a shaft on each end. To prevent the belt from sagging under the weight of material conveyed on the belt, the middle must be supported with either a continuous steel pan or a series of rollers. These supports have several variations: flat pan with sidewalls, troughing pans, flat roller with side walls, troughing rollers, or cable rollers.

In certain sections of the system, heavy duty steel apron conveyors are used because of their impact-absorbing capability and they are less susceptible to belt damage than are rubber belt conveyors.

b) Crushing/Reducing Equipment

Size reduction is the operation in which materials are mechanically reduced in size. In practice, the terms shredding, grinding, and milling are used interchangeably to describe mechanical size-reduction operations. The objective of size reduction is to obtain a product that is reasonably uniform and considerably reduced in size in comparison with its original form.

Size reduction equipment depends on the components of the waste stream to be reduced. Jaw and impact crushers and jackhammers are the principal reduction units used to reduce materials such as concrete, asphalt, brick, and rocks.

Hydraulic Breaker or Jackhammer

This pneumatic impact tool is used for breaking oversized material into pieces small enough to be processed by the next crusher/reduction unit in the process. The breaker tool is usually mounted to either a fixed or mobile knuckleboom.

Jaw Crusher

The jaw crusher reduces asphalt or concrete chunks to 6” inches or less. These units can easily tolerate pipe, steel, rebar, manhole lids, etc. Compressible materials such as wood and plastic tend to jam the jaws and severely reduce throughput.

Impact Crusher

Impactors are used as primary and secondary crushing units. In C&D operations that process highly commingled loads, impactors offer the most versatility. They have the capability to handle friable and nonfriable (compressible) materials. The nonfriables, which jam up other primary reduction units, tend to get sheared or mangled by the impactor’s rotors and work their way out of the reduction chamber.

Hammermills

Hammermills, also known as wood hogs, can process wood and drywall. Reduction occurs as the heavy hammers, attached to a rotating element, impact the material as it enters the unit. Product size is controlled by the screen size selected for the reduction chamber. Materials too large for the screen openings are caught on the screen or chamber walls and bounce up into suspension for impact with the hammers.

Stump Grinder

Stump grinders are large machines, often trailer-mounted and top-loaded by on-board knuckleboom loaders. The machine is more expensive than a wood hog but can handle large bulky materials. The principle for reduction of the waste material is slightly different from the wood hog hammermill. One type of the grinder uses steel teeth bolted to a rotor that cuts the material against the impact bars. Other types of stump grinders include machines with a large chipper disc arrangement and an impeller that throws material against teeth mounted on free-spinning rollers.

Rotary Shear Shredders

Shear shredders are low-speed, high-torque machines that rip and tear material apart and are ideal for primary reduction of bulky wood material, such as pallets, crates, and stumps, up to 3" to 4" in diameter.

Large units can also reduce concrete, steel drums, white goods, and furniture. Their use of low-speed rotors makes them much less susceptible to damage than their high-speed counterparts. This equipment has difficulty in processing soft, elastic, woody materials, which tend to slip through the cutters without being reduced.

Screw Shredders

In screw shredders, material is first broken down between two parallel slow-running screws with opposing threads situated at the top of the grinder. The threads catch a corner of the material and draw it down between the threads. Once per revolution, the threads meet so material that has not already been crushed is sheared by the cutting edges of the threads. These units can process bulky wood material, including tree stumps, brush, logs, scrap lumber, clean wood, pallets, trees, and yard trimmings.

c) Screening/Separating Equipment

Screening separates mixtures of materials of different sizes into two or more size fractions using one or more screening surfaces.

Grizzly Screen

This equipment consists of a feed hopper with a vibrating bottom deck of evenly spaced steel bars. The spaced bars move the oversize material forward into the crusher while the undersize material falls through the bars.

Vibrating grizzly feeders are ideal for feeding rubble and mixed C&D material to the primary crusher.

Vibrating Screen

Vibrating screens can be designed to vibrate from side to side, vertically, or lengthwise. The screen surface is housed in a rectangular box. The box may contain one or more multiple material separations.

Trommel Screen

A trommel screen is an inclined rotating cylindrical screen where the material to be separated tumbles and contacts the screen several times as it travels down the length of the screen. Small particles fall through the holes in the screen, while oversized materials pass over the screen.

Disc Screen

Disc screens consist of parallel horizontal shafts equipped with interlocking lobed (or star-shaped) discs that run perpendicular to the flow of in-feed material. Undersize material passes through the spacing between the opposing shafts and discs. Oversize material, remaining on top of the shafts, is conveyed through the length of the unit by the rotating motion of the shafts.

Air Classifiers

An air classifier is a separator which uses an air stream to separate materials based on the weight difference of the material. A vertical or horizontal air flow is used to separate dense material from less dense material. In a horizontal unit, feed material is dropped into a chamber where a horizontal stream of air (air knives) deflects the light material so that it crosses a fixed splitter and discharges separately from the heavy material. Vertical units lift the light material in a rising column of air for discharge out the top. Heavy material discharges out the bottom.

Flotation

Flotation employs water to separate wood from rubble. Before entering the tank, the material typically is screened to remove fines and is spread out to minimize bed depth. In the flotation process, rubble will sink and the wood fraction floats. Rubble is scraped from the bottom of the tank by a drag chain conveyor that inclines up and out over the tank lip. Floating material is moved by a skimmer over an in-tank barrier.

Magnetic And Electric Field Separation

Magnetic Separation. A magnetic separator is designed to remove ferrous metals from a moving bed of material. A large magnet, either permanent or electromagnetic, is mounted on a frame. Surrounding the magnet is either a rubber belt or a steel drum with vanes that travel around the magnet. This equipment is typically installed in a conveyor head pulley or suspended above a bed of material in an in-line or cross-belt fashion.

Electrostatic Separation. High-voltage electrostatic fields can be used to separate nonconductors of electricity, such as glass, plastic, and paper, from conductors such as metals. It is also possible to separate nonconductives from each other based on differences in their electrical permittivity, or ability to retain electrical charge. Thus, it is possible to separate paper from plastics. This technology is not in widespread use at this time.

Eddy Current Separation. **Eddy current separation is based on the law of electromagnetic induction. If a conductor is placed in a time-varying magnetic field, a voltage will be generated in the material. This voltage will cause a current to flow and induce a magnetic field that is opposite in polarity to the applied time-varying field, thus producing a magnetic force, which will repel the conductor out of the magnetic field. A time-varying field can be created either by rapidly reversing the voltage on an electromagnet or by using strips of permanent magnets with alternating polarities.**

Manual Picking Station

A manual picking station is an elevated platform with a conveyor and a catwalk along both sides of the conveyor. Manual sorting is done by removing specified items from the conveyor and dumping them in the appropriate chute provided.

5. References

1. Donovan, Christine. “Construction and Demolition Waste Processing: New Solutions to an Old Problem,” Resource Recycling, August 1991, p. 146-155.

2. Filtz, Russel et al. “New C&D Processing Technologies,” August 1993, p. 28-32.

3. Filtz, Russel et al. “Move It, Smash It, Screen It: Processing Equipment for C&D,” Resource Recycling, August 1993, p. 34-43.

4. Tchobanoglous, George et al. Integrated Solid Waste Management Engineering Principles and Management Issues. McGraw-Hill, Inc. 1993.

C. Sample Instructions to Proposers: Port of Portland

INSTRUCTIONS TO PROPOSERS

Article 1 - Description

A. Labor, materials, transportation, equipment, and other means required to complete the work in accordance with the contract documents.

B. Except where the words or context clearly require a different result, the Port intends its technical specifications to be performance specifications that either establish performance requirements or illustrate concepts or levels of quality,

C. Alternate concepts methods, or materials; innovative ideas; and the latest state-of-the-art developments are welcome and encouraged provided they are fully explained in the Proposal.

Article 2 - Examination of Site

A. A proposer intending to submit a proposal is encouraged to examine the work site prior to the Proposal submittal due date.

B. Site examinations shall be with a Port escort, by appointment only, and during normal working hours (8 a.m.. to 5 p.m., Monday through Friday). Schedule appointments at least 24 hours in advance. Make arrangements through the Project Engineer.

Article 3 - Interpretation of Contract of Documents

A. If discrepancies or omissions are found or if there is doubt as to the true meaning of any part of the contract documents, submit to the Manager, Contracts and Procurement, a written request for a clarification or interpretation thereof not later than 10 days prior to the due date set for submittal of Proposals.

B. Proposers who believe that this contract document limits competition shall submit their reasons, in writing, to the Manager, Contracts and Procurement, not later than 10 days prior to the date set for submittal of Proposals.

C. Clarification or interpretation of the contract documents will be made by addendum. Consider addenda in the proposal submittal. The Port is not responsible for and Proposers should nor rely upon explanation, clarification, interpretation or approval made or given in any manner except by addendum.

Article 4 - Proposal Process

A. General:

1. The Port is requesting proposals for the dismantling of Terminal 4, Pier 2 (see project description in Section 01010, Description).
2. Only one proposal shell be described. A Proposer may submit as many Proposals as desired, but each Proposal shall be separate and independent of any other proposal.

B. Proposal Procedure;

1. This will be based on a competitive evaluation process. However, the Port reserves the right to make award on Proposal(s), as submitted, without discussions.
2. The Port is using an RFP procedure. The process includes:
    a. Issuance of the RFP by the Port.
    b. Submittal of Proposals by Proposers.
    c. Evaluation of the Proposals and any supplements by an evaluation committee.

d. Recommendation of award of contract to the Port commission, based on the most responsive Proposer and Proposal as determined by the evaluation committee. The award of the contract is subject to approval by the Port commission.

e. Each proposer still within the competitive range when a final selection is made will be informed in writing as to which Proposer is recommended for the award.

C. Protests: Any protest related to the contract award process shall comply with the following procedure;

1. A Proposer or prospective Proposer who wishes to object to any aspect of this procurement must deliver a written protest to the Port's Manager of Contracts and Procurement, 700 N.E. Multnomah, 15th floor, Portland, Oregon 97232; or P.O. Box 3529, Portland, Oregon 97208; or facsimile to (503) 731-7597.
2. If the protest relates to matters that are apparent on the face of the solicitation documents or that otherwise are known or reasonably ought to be known to the protester, the protest must be delivered no latter than ten days prior to the due date set for submittal of Proposals.
3. If the protest relates to other matters, including but not limited to the award of the contract, it must be delivered as soon as possible, and in no event later than seven days after the protester knows or reasonably ought to know of the award of the contract, the Port's intent to award the contract, or other matters to which the protest is addressed.
4. A protest is delivered for the purposes of this article when it actually is received by the Port's Contracts and Procurement staff.
5. The Port may decline to review a late protest.
6. The protest shall be deemed to include only the documents timely delivered pursuant to this article. It must clearly state all of the grounds for the protest and must include all arguments and evidence in support of the protest. Testimonial evidence may be submitted by affidavit. The Port may investigate as it deems appropriate in reviewing the protest and will issue a written response to the protest. The Port may proceed with contract award, execution, and performance while a protest is pending.

Article 5 - Proposal Submittal

A. The Proposal submittal shall consist of: 1) the properly executed Formal Proposal on the form provided, plus one copy and 2) seven complete identical bound sets of the specified Technical Proposal documents. Incomplete proposals may be deemed non-responsive and either judged to be outside the competitive range and dropped from further consideration or, at the Port's option, the Proposer may be requested to complete the Proposal. To ensure proper handling mark the proposal with the project's name in the lower left-hand portion of the sealed envelope. Proposal documents shell be deemed to include by reference each of the following:

1. Request for Proposal (RFP): The RFP (and any addenda) is the sole instrument by which the Port is soliciting Proposals.
2. Addenda to RFP:

    a. The Port reserves the right to make such changes in the RFP as it may deem appropriate. Any and all changes in the RFP will be by written addendum issued by the Port to all prospective Proposers who have been issued or obtained copies of the RFP from the Port.

    b. Any prospective Proposer may request a change in any part of the contract manual, including the RFP. Any such request shall:

        (1) Be in writing.

        (2) Identify the particular portion of the contract manual affected.

        (3) Include the specific language requested to effect such change.

(4) Contain a statement of justification which establishes the advantage to the Port in making the change.

c. It is preferred that Proposer-requested changes be submitted as early as possible.

d. The Port will evaluate any request so submitted, but reserves complete discretion to determine the desirability of any requested change. Any change desired by the Port will be the subject of an addendum and will be issued to all known prospective Proposers then remaining within the competitive range.

B. Formal Proposal:

1. The Formal Proposal shall be made only on the form provided.

2. The Formal Proposal shall be the Proposer's price for all labor, materials, equipment, dismantling, processing, recycling, management, contracting, hazardous waste management, permitting, removal, disposal, and transportation necessary to complete the work.

3. The Formal Proposal will be executed in the name of the firm followed by the signature of the officer authorized to sign for the. firm and the printed or typewritten designation of the officer's name and office held.

4. The address and telephone number of the Proposer shall be typed or printed on the form.

C. Technical Proposal: In the Technical Proposal, the Proposer shall describe in detail the work plan, services and equipment be provided in order to meet the requirements of the RFP. The Technical Proposal must clearly describe the capabilities of the Proposer, the characteristics of the proposed work, and the proposed subcontractors. The document shall include the information and be organized in the form described below:

1. Proposed work procedures, dismantling plan, and waste management plan.

a. Provide a detailed material dismantling sequence plan and schedule for the removal of Pier 2.

b. Provide salvaged, recycle, and disposal percentages of all materials. See Section 02055 for a list of anticipated materials. Include any materials not identified

(1) Proposers are encouraged to maximize material recycling/re-utilization percentages.

(2) The following weighted values for material recycle re-utilization will be used in the evaluation of proposals. The value assigned to the material is an important factor for that material.

Timber	60
Concrete	30
Asphalt	5
All others	5

(a) In evaluating the recycling component of the proposal, the Port will give most weight to salvage and re-utilization of the suitable materials. Resource recovery for fiber, hog fuel, and compost will be of secondary importance.

c. Identify laydown and processing area requirements for the storage, handling, shipping, etc., of the dismantled materials.

d. Identify hazardous waste removal, containment, monitoring, reporting, and disposal area operations, and requirements.

e. The proposer shall submit a Waste Management plan for the removal and prevention of contamination of recyclable materials. The plan shall include the items indicated below:

(1) Asbestos Abatement:

(a) Submit Contractor's License, worker certification records, written respirator program and medical monitoring program.

(b) Submit a written work plan which describes site-specific removal and disposal methods; decontamination procedures; and plans for construction of demarcated work areas, decontamination enclosure systems, and for isolated work areas. The plan shall schedule the systematic: flow of work throughout the building on a weekly basis and shall indicate when each area or particular rooms are off-limits to others.

(c) Submit information pertaining to the proposed Air Monitoring program for this project including the name of the industrial hygiene firm performing the employee monitoring and the name of the firm's staff Certified Industrial Hygienist (CIH) supervising the employee exposure monitoring program. This information shall include the name of the on-site industrial hygienist working under CIH supervision, types of equipment, sampling schedule, type and frequency of tests, sampling procedures, calibration, recordkeeping and proposed testing laboratory.

(2) Lead-Painted Materials Mitigation:

(a) The proposer shall develop a written, site-specific lead compliance program. The program shall be either written or reviewed by a Certified Industrial Hygienist, certifying that the program is site-specific and satisfies all governing regulations. The lead compliance program must identify the program administrator, site-specific work plan, schedule, description of work practices, competent person and crew, lead training documentation, equipment and materials, specific engineering controls, air monitoring program, medical surveillance program, respiratory protection program, hygiene facilities and practices, waste disposal programs, and hazard communication program for contractors on multi-contractor sites.

(b) Submit information pertaining to the proposed Air Monitoring Program for this project including the name of the industrial hygiene firm performing the employee monitoring and the name of the firm's staff Certified Industrial Hygienist (CIH) reviewing the employee exposure monitoring program. This information shall include the name of the on-site industrial hygienist working under CIH supervision, types of equipment, sampling schedule, type and frequency of tests, sampling procedures, calibration, recordkeeping and proposed testing laboratory.

2. Identify material markers.

   a. Identify markets for all materials that are removed from this project.

   b. Provide contact names and telephone numbers which identify the markets or end uses of the salvaged material.

3. List all deviations from these specifications. Identify specification item, nature of the deviation, and explanation. List items referencing the Port's page number and specific paragraph number. If no deviations are identified and the Proposal is accepted by the Port, the Proposer shall conform to all the requirements specified.

4. Unless the Proposer expressly identifies a proposed deviation as specified above, a conflict or inconsistency between any language in the RFP and the Proposer's Proposal shall be resolved in favor of the language in the RFP.

5. The Port recognizes that there may be elements of the proposals considered proprietary by Proposer. A Proposer must identify in his Proposal any information, drawings, or design details which he considers to be proprietary. Subject to the requirements of evaluation of Proposals and public disclosure laws, the Port will endeavor to protect against unnecessary disclosure of any information, drawings, or design details so designated.

6. Qualifications and Experience Record of the Proposer: Include a written response to the following items. The response shall be arranged and lettered or numbered to match the following format:

a. How long has the Proposer been dismantling/recycling structures?

b. How many projects similar to the one in this proposal has the Proposer completed?

c. Proposer’s years in the demolition/dismantling, recycling, contracting business.

d. Value of yearly demolition/dismantling contracts.

e. Provide history of each project completed that is similar to the Terminal 4, Pier 2 Dismantling project, including:

(1) Location of projects including name and address of contact person, starting with the most recent, within the last five years,

(2) Type of project (over water or on land, dock, warehouse, building, piles, etc.).

(3) Square footage.

(4) Types of materials removed.

(5) Recycle/disposal percentages of materials removed.

(6) Quantity of materials removed, i.e., square footage of roofing; board feet (in thousands) of "x" by "x" timber "type"; square footage or cubic yards of concrete; cubic yards of fill; etc.

(7) Environmental applications for removal and disposal of materials.

(8) Project costs for dismantling/disposing, revenues generated from salvaged materials, and total project cost.

(9) Subcontractors used for dismantling/disposal.

(10) Material brokers.

(11) Schedule/duration for completing project.

f. If the Proposer plans to do some portions of the work and subcontract other portions of the work, describe how the overall responsibility is going to be coordinated and shared.

g. Provide detailed financial information which will enable the Port to determine the financial ability of the Proposer to perform.

h. Provide insurance and surety coverage which will enable the Port to determine the financial ability of the Proposer to perform.

i. Provide detailed information on the business organization of the Proposer.

j. Provide the Proposer's latest three years of audited financial statements. Statements are to include Balance Sheet, Income Statement, Statement of Changes in Equity, and Statement of Cash Flow.

7. Project schedule.

   a. The Proposer shall submit a project schedule for the dismantling and removal of the Pier 2 materials.

   b. The schedule shall include duration of the project and identify seasonal requirements for aspects of the material removal, i.e., piling removal during low river stages, etc.

8. Proposed chances to scope.

   a. The Proposer may present methods or procedures which result in changes to the scope of the work.

   b. Changes in scope shall benefit the project in increased reutilization of the materials, and reduced project duration and cost.

   c. Changes to the scope shall be clearly defined and described.

d. Changes in scope which are not clearly identified and described may not be considered in the final evaluations.

e. The Port may select and include any number of proposed changes in the final agreement.

D. Supplements to Proposals: If the evaluation of any Proposal indicates minor noncompliance with or variance from the technical provisions of the RFP, the Port may, but need not, make a written request to the Proposer for a Proposal Supplement. Such request will attempt to identify the noncompliance or variance, request additional information, and establish a date by which a Proposal Supplement must be submitted. To remain responsive, the Proposer shall submit a Proposal Supplement responsive to such request, within the time period established in such request, which the Port will receive and evaluate in conjunction with the Proposal. Any Proposal Supplement so submitted and approved will thereafter be deemed to be an integral part of the Proposer's Proposal. Except as herein provided, Proposals shall not be changed, modified or withdrawn earlier than provided for in the Formal Proposal.

Article 6 - Evaluation of Proposals

A. The Port reserves the right to determine that any or all Proposals are unacceptable or to reject all Proposals. An evaluation committee will be appointed by the Port to evaluate Proposals. The committee may schedule meetings in Portland with Proposers in the competitive range, either individually or collectively, as may be appropriate, to establish uniform interpretation of the RFP or to address issues of common interest. The evaluation committee will evaluate the Proposers and Proposals and determine the most responsive Proposer. A recommendation of contract award will be based on the committee evaluation.

B. If a Proposer submits more than one Proposal, each Proposal will be evaluated independently. Evaluation of Proposals will be based on consideration of the following items listed in descending order of priority with the most important listed first.

1. The degree to which the Proposal meets the requirements specified in the RFP
2. Cost.
3. Material re-utilization percentages.
4. Schedule.
5. Business find financial stability of the Proposer.

Article 7 - Proposal Security (Bid Bond)

A. A certified or cashier's check or a proposal bond (bid bond) payable to The Port of Portland in an amount equal to at least 10 percent of the total amount of the Proposal shall accompany each Proposal as proposal security and as a guarantee that the Proposer will execute the agreement and provide a performance and payment bond. In the event more than one Proposal is submitted, the amount of proposal security shall be 10 percent of the amount of the Proposal with the greatest price. The successful Proposer's check or proposal bond will be retained until he has executed the Agreement and furnished a 100 percent performance and payment bond.

B. The proposal bond shall be fully executed by a surety company licensed to do business in the State of Oregon.

C. Should the successful Proposer fail to execute and deliver the contract documents, including a satisfactory performance and payment bond, within 20 days after date of letter of award, the contract award may be canceled by the Port and the proposal security forfeited to the Port.

Article 8 - Submission of Proposal

A. Each Proposal shall be sealed in a separate envelope, addressed to the Manager, Contracts and Procurement, The Port of Portland, 700 N.E. Multnomah Street, Portland, Oregon, 97232 (mailing address: P.O. Box 3529, Portland, Oregon 97208) showing on the outside of the envelope the name of the Proposer and the RFP title preceded by the words “PROPOSAL.”

B. Proposals will be received at the place and until the time stated in the RFP.

C. Any Proposal received after the scheduled date will be returned unopened .

Article 9 - Withdrawal of Proposal

A. At any time prior to the scheduled Proposal submittal due date, a Proposer may withdraw his Proposal, This will not preclude the submission of another Proposal by such Proposer prior to the time set for receiving Proposals.

Article 10 - Opening of Proposals

A. The Port reserves the right to postpone the Proposal submittal due date.

B. There will be no public opening of Proposals. Contents of Proposals will not he made public information until the evaluation committee has made its recommendation of award, subject to the withholding of trade secret or other information not subject to public disclosure under Oregon law.

Article 11 - Execution of Agreement and Performance and Payment Bond

A. Upon acceptance, the successful Proposer shall execute and deliver the agreement and the performance and payment bond for the total amount of the agreement, fully executed by a surety company authorized to do business in the state of Oregon. The agreement and the performance and payment bond shall be on the form provided by the Port.

Article 12 - Notice to Proceed.

A. The Port will issue Notice to Proceed after execution of the agreement by the Port. The Notice to Proceed will state the date on which the Proposer is to begin work and the date by which the Proposer will be required to complete the work.

D. Lists

The following lists are available from the Integrated Waste Management Board. Lists 1–4 are available from the Board's Public Affairs Office and through the on-line Publications Catalog on the Board's Internet Web site (see contact information on the inside front cover of this report). They are updated by staff as needed.

List 5 (SRRE Coordinators) is available from the Office of Local Assistance.

1. Construction and Demolition Recyclers—Processors and Receivers

This list is in spreadsheet form. It contains approximately 500 entries of sites in California that receive construction and/or demolition materials for recycling or reuse. It is sorted alphabetically by county. The material categories include asphalt, concrete, brick, appliances, flooring, glass, drywall, paint, plastic, and wood. Listings contain address, phone number, and in some cases a short description of specific materials accepted. (Publication #431-96-017).

2. Construction and Demolition Recycling—Organizations & Publications List

This list is in spreadsheet form. It contains approximately 70 entries of C&D recycling publications and associated organizations which could be non-profit, business, and/or government. (Publication #431-96-019)

3. Model Buildings with Recycled-Content Products.

This list is in spreadsheet form. It contains approximately 21 entries of structures built with recycled-content building products. (Publication #431-96-020).

4. Construction Products with Recycled Content.

This list is in spreadsheet form. It contains the names of approximately 450 manufacturers (and a few distributors) of recycled-content construction products sold in California. Most of these entries are located in California. The database is sorted alphabetically by county or state. The product categories include aggregate, asphalt, masonry, structural, flooring, walls, insulation, fixtures, paint, roofing, wood substitutes, and outdoor products. (Publication #431-96-018).

5. Source Reduction and Recycling Element (SRRE) Coordinator List.

This list gives the names, titles, and phone numbers of local government staff contacts responsible for planning and implementing waste prevention, recycling, and composting programs for each jurisdiction in California. For the most current list, call the Board's Office of Local Assistance at (916) 341-6199.

E. Fact Sheets.

The following fact sheets are available from the Board's Public Affairs Office and through the online Publications Catalog on the Board's Internet Web site (see contact information on the inside front cover of this report). They are updated by staff as needed.

1. Recycled Aggregate

This fact sheet contains an overview of recycling concrete and asphalt into aggregate. It includes a brief summary of the Greenbook and CalTrans specifications, related organizations, and siting considerations in California. (Publication #431-95-052).

2. Asphalt Pavement Recycling

This fact sheet contains an overview of recycling asphalt pavement back into asphalt pavement. It includes information on recycling methods, Greenbook and CalTrans specifications for road base, organizations, and siting considerations in California. (Publication #431-95-067).

3. Drywall Recycling

This fact sheet contains an overview of drywall recycling with information on existing and potential markets for gypsum, drywall processors in California, and a list of reports. (Publication #431-95-069).

4. Construction Product Approval Process

This fact sheet is a brief guide, which includes an appendix, outlining suggested steps to take a new recycled-content construction product through the code approval process. It also includes a reference to organizations involved in the approval process, such as model code agencies. (Publication #431-96-021).

5. Urban Wood Waste

This fact sheet gives a brief overview of the types and quantities of wood waste generated from most construction and demolition operations. A discussion of potential markets for the processed wood waste is also included. (Publication #443-95-057).

6. Lumber Waste

This fact sheet gives a brief overview of the options and current practices being employed to reuse whole or remilled lumber generated from construction and demolition activities. It includes a partial list of organizations that either salvage, remill, and/or regrade whole used lumber. (Publication #443-96-028).

7. Job Site Source Separation

This fact sheet gives several options a contractor should consider that might enhance the likelihood of recycling wastes generated from construction or demolition activities. (Publication #443-95-066).

8. Carpet

This fact sheet gives an overview of carpet reuse and recycling practices. It also contains a list of facilities that accept used carpet. (Publication #443-96-027).

9. Asphalt Roofing

This fact sheet contains an overview of possible recycling options for asphalt roofing scrap. Reuse options include use in asphalt pavement, temporary pavement, and pothole patch. (Publication #443-96-023).

10. Waste Exchanges

This fact sheet contains a list of North American waste exchanges. (Publication #443-96-025).